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Research Article

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Growth, dry matter production of avocado (*Persea americana* Mill.) seedlings and soil physico-chemical properties as affected by organic and inorganic nutrient sources

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Summary

A lath house trial involving four doses of inorganic N and P and six types of organic potting materials was undertaken in the Jimma Agricultural Research Centre in the year 2011 to determine the effect of organic and inorganic nutrient sources on the soil physico-chemical properties, growth and dry matter production of avocado seedlings. Four levels of inorganic N and P (N_0P_0, $N_{150}P_{200}$, $N_{300}P_{400}$ and $N_{450}P_{600}$ mg/pot) as the first factor and five organic materials, FYM (farmyard manure), FD (farmyard manure mixed with decomposed coffee husk), DCH (decomposed coffee husk), UCH (un decomposed coffee husk) and UF (un decomposed coffee husk mixed with farmyard manure), including TS (Top soil) as the second factor were evaluated in a Randomized Complete Block Design with three replications. Avocado shoot (plant height, stem girth, number of leaves and leaf area) and root growths (root girth, primary root length and lateral root length) were significantly ($p < 0.01$ or $p < 0.05$) affected by the independent effect of organic and inorganic nutrient sources. The lowest and highest shoot growths were recorded at N_0P_0 and $N_{300}P_{400}$ of fertilizer application, respectively. Most vigorous shoot growths were recorded from seedlings grown in TS:DCH (2:1) followed by (TS:FYM (2:1). Media prepared from TS: UCH (2:1) had the least avocado shoot and root growths. Seedlings grown on decomposed organic materials produced higher amount of root growth in the order: TS : FYM (2:1)>TS:FD (2:1)>TS:DCH (2:1). Media prepared from TS:UCH(2:1)+N_0P_0 and TS:DCH (2:1)+$N_{450}P_{600}$ resulted significantly the lowest and the highest shoot dry mass, respectively. TS : FYM (2:1)+$N_{300}P_{400}$ produced the highest total dry matter followed by TS:DCH (2:1)+$N_{450}P_{600}$. The lowest total dry matter, on the other hand, was obtained from TS:UCH (2:1) + N_0P_0. Decomposed organic materials incorporated into the growing media had significantly improved the water holding capacity of the media at both the permanent and field capacity. The decomposed organic materials, in particular, had a positive influence on most chemical properties considered during the study (Total N, available P, Organic carbon, pH, CEC and EC).With the increase in the rate of application of inorganic NP fertilizers, the pH and EC of the growing media had accordingly decreased; Total N and available P, on the other hand, had improved. Apart from independent effects, the electrical conductivity of the growing media was also significantly affected by the interaction of organic and inorganic source of fertilizers. In conclusion, most vigorous avocado seedlings under lath house condition was obtained by amelioration of the growth media using TS : FYM(2:1) +$N_{300}P_{400}$ followed by TS: DCH (2:1) + $N_{450}P_{600}$.

Key words : Growth, Dry matter, Inorganic fertilizer, Organic materials, Seedlings, Shoot, Root growths, Physical, Chemical properties

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Introduction

Avocado (*Persea americana* Mill.) is currently grown in parts of Ethiopia which are climatically hot humid and receiving higher amount of rainfall per annum. Reports reveal that farmers growing avocado in Ethiopia have been benefiting a lot through generation of income and achieving food self-sufficiency. Equally, traders and whole sellers also benefit from avocado transaction through income generation and employment creation (Zekarias *et al*., 2006).

Despite the potential of the country to produce high yield and good quality avocado, there is scant information and scientific findings on improved pre and post harvest agricultural practices. Thus, in view of the importance attached to avocado in Ethiopia, it becomes imperative to standardize the nursery practices in order to produce avocado seedlings which are healthy, graftable and easily established in the field.

Deforestation and high rainfall in southwest Ethiopia, where avocadoes are largely growing, does make the soil more acidic (pH 4.5 - 6.5) and poor in fertility. As a result the soil has high P-fixing capacity. Thus, to grow crops in the area in general and avocado in particular, soils should be ameliorated with agricultural practices that are economically viable and environmentally friendly. In this regard, Paulos (1994) reported that application of large amount of artificial fertilizers is needed to make the soil productive in this area. However, due to the increasing price of inorganic fertilizers, the use of organic materials available around the area supplemented with some inorganic fertilizer is important to improve the soil fertility both at the nursery and field conditions. The practice of integrated nutrient management is also reported to be important for better nutrient use efficiency and growth of the plants than the use of organic and inorganic nutrient sources alone (Grohn *et al*., 2000). The sole use of organic materials as soil amendment has also its own drawbacks that the amounts of nutrients and their release rate is woefully inadequate to meet the demands of the crop production (Arora, 2002).

Organic materials containing Ca can effectively combat aluminum toxicity and raise the availability of P in the soil by forming organic complexes with Al, Fe and Mn (Sanchez and Sons, 1976 and Foth and Ellis, 1997). Thus, from economic point of view and easy availability of organic materials around the coffee growing areas of Ethiopia, it is beneficial and practical to apply locally available organic materials to the soil to amend the soil acidity.

Therefore, in view of the above and considering the economic importance attached to avocado in Ethiopia, a study on the effects of organic and inorganic nutrient sources on the growth, dry matter production and soil physico-chemical properties was undertaken.

Objectives :

- To study the effects of organic and inorganic nutrient sources on growth and dry matter production of avocado seedlings
- To study the effects of organic and inorganic nutrient sources on some soil physico-chemical properties.

Resource and Research Methods

The study area :

The study was conducted in a lath house at Jimma Agricultural Research Centre, which is located 8 km west of Jimma and 343 km south-west of the capital, Addis Ababa and situated at an altitude of 1750 m a.s.l. The Center is located at 7o 30’ N latitude and 36o 57‘ E longitude.The mean maximum and minimum temperatures are 26.3 and 11.6 ^{o}C, respectively and with a mean total annual rainfall of 1572 mm. The predominant soil of the Center is Eutric Nitisols (Paulos, 1994) with an average pH of 5.3 (Sahlemedhin and Ahmed, 1983). The physico chemical property of the top soil used during the experiment is described in Table A.

Experimental design and procedures :

The study involved 24 treatment combinations arranged in a Randomized Complete Block Design

Table A : Selected physico - chemical properties of the soil used for the study

Characters	Values
Texture	Sandy clay
Bulk density (g/cm^3)	1.09
Moisture content	
Field capacity (%)	37.5
Permanent wilting point (%)	26.74
pH (1:2.5)	5.24
EC (mS/cm)	0.20
Organic carbon (%)	2.01
Available phosphorus (ppm)	2.21
Total nitrogen (%)	0.12
Cation exchange capacity (cmol(+)/kg)	25.1

Table B: Description of treatment combinations

Sr. No	Treatment combinations
1.	TS:UCH(2:1) + N_0P_0
2.	TS:UCH(2:1) + $N_{150}P_{200}$
3.	TS:UCH(2:1) + $N_{300}P_{400}$
4.	TS:UCH(2:1) + $N_{450}P_{600}$
5.	TS:DCH(2:1) + N_0P_0
6.	TS:DCH(2:1) + $N_{150}P_{200}$
7.	TS:DCH(2:1) + $N_{300}P_{400}$
8.	TS:DCH(2:1) + $N_{450}P_{600}$
9.	TS:FYM(2:1) + N_0P_0
10.	TS:FYM(2:1) + $N_{150}P_{200}$
11.	TS:FYM(2:1) + N_{300} P_{400}
12.	TS:FYM(2:1) + N_{450} P_{600}
13.	TS:FD(2:1) + N_0P_0
14.	TS:FD(2:1) + $N_{150}P_{200}$
15.	TS:FD(2:1) + N_{300} P_{400}
16.	TS:FD(2:1) + N_{450} P_{600}
17.	TS:UF(2:1) + N_0P_0
18.	TS:UF(2:1) + $N_{150}P_{200}$
19.	TS:UF(2:1) + N_{300} P_{400}
20.	TS:UF(2:1) + N_{450} P_{600}
21.	TS + N_0P_0 (control)
22.	TS + $N_{150}P_{200}$
23.	TS + N_{300} P_{400}
24.	TS + N_{450} P_{600}

UCH = Un decomposed coffee husk; DCH = Decomposed coffee husk; FYM = Farmyard manure; UF = Un decomposed coffee husk mixed with farmyard manure; FD = Decomposed coffee husk mixed with farmyard manure; TS = Top soil

(RCBD) with three replications. There were four levels of nitrogen and phosphorus (N_0P_0, $N_{150}P_{200}$, N_{300} P_{400} and $N_{450}P_{600}$ mg/pot) as the first factor; five organic materials (un decomposed coffee husk, decomposed coffee husk, farmyard manure, farmyard manure mixed with un decomposed coffee husk and farmyard manure mixed with decomposed coffee husk) and top soil alone (without organic sources) as the second factor. A check plot without organic and in organic fertilizer sources was used for the study. The details of each treatment are presented in Table B.

The top soil used for this experiment was first collected from the upper 0-25 cm of the soil surface. Before incorporating organic materials into it, the soil was air-dried and manually crushed to pass through 5 mm size sieve. The organic potting materials were air dried, manually crushed and passed through a 5 mm sized sieve before mixing with the top soil.

After mixing up of the soil and organic materials, they were filled manually into a black diothene 200 gauge polythene bags which was 25 cm long and 20 cm wide. Urea and DAP were used as a source of inorganic N and P, respectively.

Seeds of avocado fruits collected from Mexican races were then sown in each polythene bag immediately after extraction from ripened fruits. The first application of inorganic N and P fertilizers as top dressing was done when two pairs of true leaves were produced on each seedling. The second and third applications were then made at a monthly interval for two consecutive months. The fertilizers were applied after a slight hoeing with a stick and in a ring far from the trunk of the seedlings.

Collection of data :

Data on plant height, numbers of true leaves, stem diameter, leaf area, primary root girth, primary root length, lateral root length, shoot dry mass, leaves dry mass, root dry mass, total dry mass, ratio of shoot dry mass to root dry mass (S : R) were collected from six seedlings after 6 months of planting and then it was averaged for the number of seedlings. Plant height of the seedlings was recorded from the soil surface in the pots to the tip of the seedling using a ruler. The stem girth was measured at soil surface using vernier caliper. Number of true leaves, excluding the smallest ones at the tip of the seedling, was counted per sample seedling. Leaf area was determined with following equation:

Estimated leaf area = KxWxL

where,

K = Constant,

W = Maximum leaf breadth (cm) and

L = Leaf length (cm).

The root girth of each seedling was measured at point below cotyledon using caliper. Taproot length was determined using a ruler. The lateral root length, however, was taken as a mean from three longest lateral roots emerging from primary root of each seedling. The shoot and root dry mass were determined after oven drying the samples in a forced air circulation hot air oven set at 70^0C until constant weight. The total dry mass of the seedlings was calculated as the sum of shoot and root dry masses. The ratio of shoot to root dry mass (S: R) was obtained by dividing shoot dry mass by root dry mass.

At the time of seedling harvesting, soil samples were taken from six pots of each treatment and composite. Accordingly, the bulk density of the soil was determined with the method described by Okalebo *et al.* (1993) on oven dry weight basis. The water holding capacity of the soil at field capacity and permanent wilting point were analyzed using the pressure membrane and pressure plate method (Black, 1965). The soil reaction (pH) was determined with a glass electrode pH meter on a 1:2.5 soil water suspensions. The electrical conductivity (EC) was measured with an electrical conductivity meter in one part soil to two and half parts water ratio (Okalebo *et al.*, 1993). Total nitrogen was analyzed by the modified Kjeldahl method as described by Jackson (1958). Available P was analyzed using the Bray II method as outlined by Bray and Kurtz (1945). The organic carbon was determined by oxidation of organic carbon with potassium dichromate following the procedure of Walkley and Black (1934). The cation exchange capacity (CEC) was determined with a neutral ammonium acetate displacement as described by Okalebo *et al.* (1993).

Statistical analysis :

Data processing and all statistical analysis were performed with SAS and Mstat C computer programmes. Comparison of means of treatments was done at 0.01 and 0.05 levels of probability.

Research Findings and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Shoot and root growth :

N and P as well as different organic potting materials

Table 1 : Shoot growth of avocado seedlings as affected by types of organic fertilizers and levels of inorganic fertilizer

Inorganic fertilizer (mg/pot)	Plant height (cm)	Stem girth (cm)	Leaf number	Leaf area (cm^2)
N_0P_0	49.09c	0.81c	20.23 (1.29)c	51.09d
$N_{150}P_{200}$	57.35b	0.87b	23.85 (1.37)b	56.99c
$N_{300}P_{400}$	62.95ab	0.91ab	26.29 (1.41)a	62.06ª
$N_{450}P_{600}$	64.45ab	0.93ª	26.91 (1.42)a	64.38ª
	**	*	*	**
CV (%)	7.8	5.59	3.01	6.84
S.E.±	1.08	0.012	0.009	0.95
Organic material				
TS:FYM (2:1)	63.32b	0.93a	28.25 (1.44)a	60.19b
TS:FD (2:1)	61.27b	0.91a	24.87 (1.39)b	59.83b
TS:DCH (2:1)	69.0a	0.93ª	29.47 (1.47)a	66.78ª
TS:UCH (2:1)	42.42d	0.77c	17.80 (1.25)d	50.42d
TS:UF (2:1)	54.56c	0.84b	21.37 (1.33)c	54.85c
TS	60.19b	0.87ab	24.16 (1.37) b	59.73b
	**	**	*	**
CV (%)	7.8	5.59	3.01	6.84
S.E. ±	1.32	0.014	0.012	1.16

* and ** indicate significance of values at P=0.05 and 0.01, respectively Means followed by the same letter (s) are not significantly different.
Values in bracket are means of logarithmically transformed data.

had significant effect ($p<0.01$ or $P<0.05$) on both the shoot and root growths of avocado seedlings. As the dose of the fertilizers increased from Nill to N_{300} P_{400}; the shoot height, the stem girth, the number of leaves and the leaf area have simultaneously increased (Table 1). The result could probably be ascribed to the availability of more amounts of inorganic N and P in the growth media that favors the growth of the seedlings. This corroborates with the findings of Chane (1991); Taye (1998) and Anteneh (2002) that coffee seedlings continuously increased in height with the rise in the rate of application of inorganic fertilizers. The thicker root girth, longer and thicker primary and lateral root are generally obtained from seedlings raised in medias that received higher rate of inorganic NP. The result could possibly be accounted to the availability of more amount of inorganic N and P in the growth media that initiated the lateral and down ward growth of roots of avocado seedlings. In this line, Heeraman *et al.* (2001) noticed stimulated root growth of *Zorro fescue* with increased application of N fertilizer.

There had also been a significant ($p<0.05$ and $p<0.01$) growth performance differences amongst avocado seedlings grown in medias amended with different types of organic materials. Media prepared from decomposed coffee husk, farm yard manure, the mixture of farm yard manure and decomposed coffee husk had produced seedlings with vigorous roots and shoots. The longer plant height, more number of leaves and large sized leaves were generally recorded from media prepared from TS: DCH (2:1), TS:FYM (2:1) and TS:FD (2:1). Media prepared from un decomposed coffee husk either singly or in combination with the farm yard manure, on the other hand, had produced poor seedlings. The poor physical and chemical properties of growing media prepared from un decomposed organic materials might have resulted in poor infiltration of water down into the pots and inability of the media to provide the necessary nutrient elements to the plants on the desired time. The result is supported by Edossa (2001) that with the incorporation of decomposed farmyard manure and decomposed coffee pulp, avocado seedlings become vigorous. The higher records of seedling root girth and longer lateral roots were generally obtained from seedlings grown in the pots filled with TS:FYM (2:1), TS:FD (2:1), TS:UF(2:1) and TS (Table 2). The findings of the present study could possibly be accounted to the good physical environment rendered by decomposed organic materials in terms of water holding capacity, low bulk density and aeration. The smallest size of root growth from media ameliorated with un decomposed coffee husk could probably be ascribed to the poor

Table 2 : Root growth of avocado seedlings as affected by types of organic fertilizers and levels of inorganic fertilizers

Inorganic fertilizer (mg/pot)	Root girth (cm)	Primary root length (cm)	Lateral root length (cm)
N_0P_0	0.98c	21.51d	15.11c
$N_{150}P_{200}$	1.05b	22.47c	16.68b
$N_{300}P_{400}$	1.09ab	23.41b	18.58ab
$N_{450}P_{600}$	1.12^a	24.43^a	18.82ab
	*	**	**
CV (%)	5.97	3.97	7.56
S.E.±	0.015	0.21	0.308
Organic materials			
TS:FYM (2:1)	1.11^a	24.21^a	20.05^a
TS:FD (2:1)	1.09^a	24.18^a	18.71ab
TS:DCH (2:1)	1.09^a	23.67^a	17.86bc
TS:UCH (2:1)	0 .95b	20.97b	14.50e
TS:UF (2:1)	1.07^a	21.48b	16.47cd
TS	1.06^a	23.23^a	16.20d
	*	**	**
CV (%)	5.97	3.97	7.56
S.E. ±	0.02	0.26	0.38

*and ** indicate significance of values at P=0.05 and 0.01, respectively   Means followed by the same letter (s) are not significantly different

nutritional status and un favourable physical condition of the soil that hindered the growth of the seedlings. In conformity with this finding. Abebe *et al*. (2002) reported that the root collar diameter of *Calliandra calothyrsus* was found to be significantly higher when farm yard manure was used in the potting media than the top soil only.

Dry matter production of avocado seedlings :

The dry matter accumulation in the shoot parts of avocado seedlings and also the total dry mass was found to be significant ($P < 0.01$ or $P < 0.05$) in relation to the interaction of organic and inorganic nutrient sources (Table 3). The accumulation of dry matter in the root parts of the seedlings, on the other hand, was only significantly affected by the main effects of organic and inorganic sources of fertilizers. The ratio of shoot to root dry matter of avocado seedlings varied significantly ($P < 0.01$) with the type of organic materials (Table 3).

Avocado seedlings harvested from growth media prepared from TS:DCH (2:1)+$N_{450}P_{600}$ had the highest (27.41g) shoot dry mass followed by TS:DCH (2:1)+ $N_{300}P_{400}$ (26.49 g) and TS:FYM(2:1)+$N_{300}P_{400}$ (25.78 g), in that order. Due to poor physical and chemical conditions

Table 3 : Shoot dry mass of avocado seedlings as affected by the interaction of organic and inorganic nutrient sources

Organic materials	Inorganic fertilizers (mg/pot)			
	N_0P_0	$N_{150}P_{200}$	$N_{300}P_{400}$	$N_{450}P_{600}$
TS:FYM(2:1)	18.54ghi	21.91def	25.78abc	23.2cde
TS:FD(2:1)	18.54ghi	20.53efg	23.17cde	21.73def
TS:DCH(2:1)	21.87def	24.29bcd	26.49ab	27.41a
TS:UCH(2:1)	9.73n	12.28m	13.3 1m	14.2klm
TS:UF(2:1)	15.2jkl	16.52ijk	16.99hij	17.0hij
TS	14.7jklm	19.44fgh	23.5cd	23.82cd
CV(%)		7.38		
S.E.±		0.83		

Means followed by the same letter (s) with in a column and a row are not significantly different at 5 per cent of probability level

Table 4 : Root dry matter production and shoot to root dry mass of avocado seedlings as affected by types of organic materials and levels of inorganic nutrient sources

Inorganic fertilizers (mg/pot)	Root dry mass (g)	Shoot to root ratio (S/R)
N_0P_0	4.34c	3.70
$N_{150}P_{200}$	5.60b	3.46
$N_{300}P_{400}$	6.12ab	3.40
$N_{450}P_{600}$	6.00ab	3.43
	**	NS
CV (%)	11.42	11.3
S.E.±	0.12	0.09
Organic materials		
TS:FYM (2:1)	6.60a	3.41cd
TS:FD (2:1)	5.91b	3.32bc
TS:DCH (2:1)	5.60b	4.43[a]
TS:UCH (2:1)	3.91d	3.04e
TS:UF (2:1)	5.04c	3.19de
TS	4.90c	3.90ab
	**	**
CV (%)	11.42	11.3
S.E.±	0.15	0.12

* and ** indicate significance of values at P=0.05 and 0.01, respectively NS=Non-significant

Means followed by the same letter or no letters are not significantly different.

of the medium, the accumulation of shoot dry matter was smallest (9.73 g) in seedlings grown in TS:UCH (2:1) + N_0P_0. Seedlings raised in the control treatment (TS+N_0P_0) exhibited higher amounts of shoot dry matter compared to seedlings harvested from TS:UCH (2:1) at all levels of inorganic fertilizers. This could probably be attributed to the formation of poor soil structure as a result of incorporation of un decomposed coffee husk into the growing media. Moreover, the compactness of the growth media might have caused impedance on the down ward movement of applied in organic N and P that were necessary for growth of the seedlings.

Each successive increment of inorganic N and P application into the growth media resulted in a significant ($p < 0.01$) response of root dry matter (Table 4). The result depicts the role of in organic N and P in promoting the root growth of avocado seedlings. The result also substantiates the report by Tisdale and Nelson (1975) that when soluble phosphate compounds are applied in band, plant roots proliferate extensively in that area of treated soil. The lower root dry masses were also recorded from growing media ameliorated with un decomposed organic materials which is ascribed to low availability of essential nutrients coupled with poor soil physical condition from un decomposed organic materials; it could also be attributed to immobilization of available nutrients by micro-organisms during multiplication (Sanckez, 1976). The narrowest shoot to root dry matter ratio observed from seedlings raised in media prepared from un decomposed coffee husk (Table 4) could possibly be due to the higher amount of shoot dry matter produced by seedlings grown in TS:DCH (2:1), in one hand and the lower root dry matter from seedlings grown in TS, on the other hand.

Avocado seedlings receiving farmyard manure and inorganic N and P at the rate of $N_{300}P_{400}$ (TS:FYM (2:1) + $N_{300}P_{400}$) gave the highest total dry matter followed by those treated with decomposed coffee husk combined with $N_{450}P_{600}$ (TS:DCH(2:1)+$N_{450}P_{600}$).Seedlings grown in the control treatment (TS+N_0P_0) showed better dry matter production when compared with TS:UCH(2:1) +N_0P_0.TS:UCH(2:1)+$N_{150}P_{200}$ and TS:UCH (2:1)+ N_{300}

Table 5 : Total dry mass of avocado seedlings as affected by the interaction of organic and inorganic nutrient sources

Organic materials	Inorganic fertilizers (mg/pot)			
	N_0P_0	$N_{150}P_{200}$	$N_{300}P_{400}$	$N_{450}P_{600}$
TS:FYM(2:1)	24.21efg	27.99de	35.33a	29.58bcd
TS:FD(2:1)	23.23fgh	25.94defg	30.21bcd	27.62de
TS:DCH(2:1)	27.07def	29.88bcd	32.5abc	33.72ab
TS:UCH(2:1)	13.06k	16.2jk	17.55j	19.1hij
TS:UF(2:1)	19.4hij	21.73ghi	22.5ghi	22.78gh
TS	18.53ij	24.52efg	28.86cd	29.73bcd
CV (%)		6.84		
S.E.±		0.99		

Means followed by the same letter (s) with in a column and a row are not significantly different at 5 per cent of probability level.

Table 6 : Some physical properties of the growing media as affected by organic nutrient sources

	Moisture content (%)		
Organic sources	Field capacity (0.33 bar)	Permanent wilting point (15 bar)	Bulk density (g/cm^3)
TS:FYM(2:1)	44.15a	32.0a	0.80
TS:FD(2:1)	43.21a	31.13a	0.80
TS:DCH(2:1)	43.15a	31.01a	0.81
TS:UCH(2:1)	41.23b	30.16a	0.86
TS:UF(2:1)	43. 15°	30.92a	0.83
TS	37.17c	26.47b	0.93
	**	*	NS
CV (%)	3.13	7.24	12.56
S.E.±	0.38	0.63	0.03

* and ** indicate significance of values at P=0.05 and 0.01, respectively. NS= Non-significant

Means followed by the same letter or no letter are not significantly different

P_{400} (Table 5). This could be attributed to the poor physical condition of the growth media. The present result is generally in line with the findings of Patra *et al.* (2000) who reported the combined applications of manures and fertilizers significantly influenced the herb yield of mint.

Physico - chemical properties of potting media :

The moisture retained by the growth media at field capacity and permanent wilting point differed significantly ($p< 0.01$ or $p<0.05$) depending on the kinds of organic materials used to ameliorate the soil (Table 6). Even though it was non-significant, generally the bulk density of the media prepared from decomposed materials is lower than un decomposed once which indicates the positive role of organic materials in reducing the bulk density and improving the water retention capacity of the soil. Treatments involving the incorporation of farmyard manure, the mixture of farmyard manure and decomposed coffee husk, decomposed coffee husk and also the mixture of un decomposed coffee husk and farmyard manure held more amount of water at field capacity which were statistically at par. Top soil, as potting medium, held significantly lower amount of moisture (26.47 %) at permanent wilting point. The result signifies the important role of organic materials in improving the water holding capacity of the soil. In conformity to this, Sopher and Baird (1982) reported that organic matter improved soil physical conditions including aggregation and soil moisture holding capacity.

As it is evident in Table 7, with increasing application NP fertilizers from N_0P_0 to $N_{450}P_{600}$, most of the chemical characters considered during the study have simultaneously increased. The increase of N and P could possibly be due to the availability of more amount of P and N in soil solution due to the increase in the application of inorganic fertilizer. Anteneh (2002) also reported that with successive rate of incorporation of inorganic P into the growing media of coffee seedlings, the available P in the soil increased accordingly. The pH of the growing media, on the other hand, has accordingly decreased with the rise in the rate of application of inorganic NP which could be associated with the addition of hydrogen ion into the soil solution that resulted in reduction of the pH of the growing medium. The result substantiates the report of Syndor and Redente (2002) that soil acidification is intensified by the use of acid forming nitrogenous

Table 7 : Some chemical properties of the growing media as affected by levels of inorganic nutrient sources

Inorganic fertilizer (mg/pot)	pH (1:2.5)	Available P (ppm)	Total N (%)
N_0P_0	6.22[a]	43.37d	0.36b
$N_{150}P_{200}$	6.1ab	66.48c	0.39ab
$N_{300}P_{400}$	5.95b	96.90b	0.42ab
$N_{450}P_{600}$	5.74c	118.3a	0.46[a]
	**	**	*
CV (%)	3.47	12.56	18.07
S.E.±	0.049	3.34	0.017

* and ** indicate significance of values at P=0.05 and 0.01, respectively
Means followed by the same letter or no letter are not significantly different

Table 8 : Some chemical properties of the growing media as affected by types of organic materials

Organic materials	pH (1:2.5)	Available P (ppm)	Total N (%)	Organic carbon (%)	CEC (%)
TS:FYM (2:1)	6.55[a]	140.4 a	0.46[a]	5.06a	40.54[a]
TS: FD (2:1)	6.24bc	120.8 b	0.45[a]	5.08[a]	37.18b
TS:DCH (2:1)	5.82d	62.95 d	0.46[a]	5.11[a]	33.23c
TS:UCH (2:1)	6.04cd	30.39 e	0.37b	4.36c	27.39d
TS:UF (2:1)	6.36ab	97.6c	0.43ab	4.65b	33.18c
TS	5.01e	35.3 e	0.27c	2.31d	25.72e
	**	**	*	**	**
CV (%)	3.47	12.56	18.08	5.51	2.18
S.E. ±	0.06	2.73	0.02	0.07	0.21

* and ** indicate significance of values at P=0.05 and 0.01, respectively.
Means followed by the same letter or no letter are not significantly different

fertilizers.

Most of the chemical attributes (pH, EC, organic carbon, available P) have significantly improved with the addition of organic materials either alone or in combination (Table 7).

The higher pH from media amended with farmyard manure either singly or in combination with coffee husks could possibly be attributed to the release of basic cations (K, Ca, Mg and Na) and hydroxides upon decomposition (Codling *et al*., 2002). In line with this, Shanjida and Sarwar (2002) reported that wood ash materials consist of highly reactive oxides and hydroxides and more slowly reactive carbonates are responsible for neutralizing acidity in the soil. The lower amount of available P in media made from un decomposed coffee husk and top soil, in one hand, is probably due to high amount of organically bound P in farmyard manure that was released into the soil solution up on mineralization (Codling *et al*., 2002). On the other hand, this could also be possible due to decreased phosphorus adsorption capacity of the soil as a result of increased pH and blockage of adsorption sites in soil colloids by organic molecules (Iyamuremye and Dick, 1996). Conversely, due to the inherent availability of small amount of coffee husk together with the slow rate of decomposition of un decomposed coffee husk, relatively low amount of available P could have been recorded from media amended with un decomposed coffee husk. It could also be attributed to immobilization of added inorganic nutrients by numerous micro-organisms prevailing in the newly decomposing coffee husk (Sanckez, 1976). The higher amount of CEC in organically treated media, on the other hand, could most probably be attributed to the release of basic cations into the soil solution up on decomposition of the organic materials (Tolanur and Badanur, 2003).

The total soluble salts of the media were significantly affected by the combined use of organic and inorganic nutrient sources (Table 8). The highest value of total soluble salts was obtained from TS:FYM(2:1)+$N_{450}P_{600}$ and TS:FYM(2:1)+$N_{300}P_{400}$. With no addition of organic and inorganic fertilizers, the lowest amount of total soluble salts (0.17 mS/cm) was found in control treatment (TS+N_0P_0) (Table 9). The higher amount of soluble salts in media amended with farmyard manure could be accounted to the presence of more amount of soluble salts in farmyard manure that were released in to the soil solution up on mineralization.

Conclusion :

The increase in the rate of NP fertilizers into the growing media has generally resulted in the significant improvement of the shoot and root growths; the dry matter of both the shoots and the roots as well which reveals the important role of NP nutrients in satisfying the physiological need of the plant. Instead of undecomposed coffees husks used alone and mixed with farm yard manure, vigorous and graftable avocado seedlings were attained from growing media prepared from well decomposed coffee husks and farm yard manure. The result clearly signifies the need of the avocado seedlings for suitable growing media. If it is needed to produce avocado seedlings which are healthy and graftable, the soil in the area should first be treated with decomposed organic materials preferably mixed with inorganic NP fertilizer. Application organic and in organic source of nutrients have also improved the soil physico chemical properties of the growing media. As the area is specialized in the production of coffee and cattle

Table 9: Total soluble salts of the growth media as affected by the interaction of organic and inorganic nutrient sources

Organic material	Inorganic fertilizer (mg/pot)			
	N_0P_0	$N_{150}P_{200}$	$N_{300}P_{400}$	$N_{450}P_{600}$
TS:FYM (2:1)	0.61fgh	1.10[a]	1.13[a]	1.16[a]
TS:FD (2:1)	0.60fgh	0.79cdefg	0.87bcde	0.97abc
TS:DCH (2:1)	0.56ghi	0.70defgh	0.82bcdef	0.86bcde
TS:UCH (2:1)	0.34ij	0.49hi	0.79cdefg	0.93abcd
TS:UF (2:1)	0.58gh	0.68efgh	0.78cdefgh	1.05ab
TS	0.17j	0.35ij	0.54hi	0.82bcdef
CV (%)		13.04		
S.E.±		0.06		

Means followed by the same letter (s) with in a column and row are not significantly different at 1per cent of probability level

rearing are a common practice, it is not difficult to obtain coffee husk and farm yard manure used for propagation of avocado in the area. Further research to investigate the compatibility of avocado root stock with the scion material and also their establishment and yield performance under field condition should be undertaken. In addition, the role of integrated nutrient management on the soil fertility and amelioration of soil acidity should be investigated under field condition on avocado trees as to establish economically profitable levels of these agricultural inputs.

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